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Information disclosure and information acquisition in credit markets

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Abstract

We analyse how the design of credit registers can influence competition in lending markets. We focus on a particular design choice, namely whether or not credit registers should record previous loan applications that did not result to a subsequent loan origination. This design choice can have subtle effects to the extent that the fact that a prospective borrower has previously applied with other lenders for the same loan can be informative. This is particularly likely to be the case if the failed or withdrawn application was with an innovative lender that is better at screening prospective borrowers thanks to the use of Big Data-driven methodologies (eg ML and AI) alongside the traditional credit scoring approach. On the one hand, we find that when credit registers record previous loan requests rates advertised to borrowers are lower than when credit registers do not record loan requests. On the other hand, the incentives to invest in advanced screening technologies are weakened as a result.

Key words: Innovation, competition, disclosure, credit markets.

JEL classification: G2, L15, L40.

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1 Introduction

When SoFi broadcast its first Super Bowl advert in January 2016, the San Francisco-based fintech start-up had a niche strategy of refinancing the student loans of professionals with upside career prospects, a demographic labelled as HENRY ("High Earners, Not Rich Yet"). The advert in question randomly focused on a number of pedestrians on a busy urban street during the morning rush-hour, with a voiceover labeling them as either "great" or "not great." The advert was meant to end with the strapline: "Find out if you're great at SoFi.com. You're probably not." However, the final three words were removed in a last minute edit.[1]

That original strapline conveyed the impression that the lender in question had an edge in identifying creditworthy borrowers over not only competing lenders but also, and more unusually, prospective applicants. Traditionally, the presence of asymmetric information in retail financial markets is assumed to be on the side of consumers holding private information that is relevant to their risk profile. However, technological advancements enabled by big data, artificial intelligence and machine learning could flip the balance in favour of providers who are now able to infer relevant statistical correlations unbeknown to consumers.[2]

Such technological advancements mean that the decision made by a lender with a superior screening technology can provide a useful signal to competing lenders. Besides the positive signal that comes from being granted a loan by a better informed lender, a rejection can be seen as a signal of the corresponding applicant being too risky. This in turn can affect the willingness of prospective borrowers to apply for a loan with the lender in question. The positive signal derived from being granted a loan has seldom been discussed in the

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[1] See 'Here's the version of that SoFi Super Bowl ad you didn't see — it was edited because it was deemed too offensive', Business Insider, February 7 2016, available at.

[2] See, Villeneuve (2005), Brunnermeier et al. (2020) and Abrardi et al. (2020) for applications of this informed principal assumption in the insurance market.

literature, and we are not aware of attempts to model the impact of a negative signal arising from previous rejections by a better informed lender.

We compare two information regimes whereby lenders either can or cannot observe those previous applications with competing lenders that were either rejected or withdrawn. When a borrower applies for credit the lender often issues a request for the borrower's credit report and bases its decision largely on the content of this report. As well as containing information such as payment history and the current amount of credit outstanding, credit reports may or may not contain information concerning other requests that have been made for this credit report. If such information about other recent requests is recorded, this information can be used as evidence that the borrower has tried and failed to secure credit from other lenders. Hence lenders may regard recent credit requests as a negative signal of a borrower's creditworthiness, and be less likely to offer credit to borrower's with many recent credit requests recorded on their credit report.

For this reason, the UK Competition and Markets Authority (CMA) has argued that the disclosure of previous applications could distort competition by constraining the ability of prospective borrowers to shop around, given the concern that evidence of previous credit searches by competing lenders may negatively affect their scoring and thus reduce their likelihood of being approved. As a result, the CMA recommended the introduction of 'soft' searches,[3] whereby a lender can interrogate a credit history profile provided by a credit reference agency without leaving a trace. By the same token, Experian, a major credit reference agency, advises borrowers who are planning to apply for a major new credit product like a mortgage in the near future to avoid applications to any other new credit in order to keep their credit score as high as possible. This is especially relevant to small and young lenders for which there is limited amount of information that is publicly available, so that they tend to be reliant on banks as a source of external financing (Petersen and Rajan, 1994).

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[3] See 'Retail banking market investigation - Final report', CMA, 9 August 2016, p. 618.

Besides affecting the willingness of borrowers to shop around, the risk that a rejection might blemish the credit profile of the applicant could also affect the incentive of the lender to invest in advanced screening technologies in the first place. This is to the extent that prospective borrowers prefer not to apply for a loan from a lender known to have a superior screening methodology, in order to avoid the risk of being rejected which would penalize them when subsequently applying with other lenders. When the borrower is uncertain about the outcome of an application with a lender with a superior screening technology, there is both an upside and a downside risk. With regards to the former, acceptance would mean being accredited as being creditworthy thus benefiting from lower future lending rates even from the lender with a screening disadvantage. If the downside risk is dominant, the initial investment required to adopt the superior screening technology would not be viable as the lender in question might fail to attract sufficient applicants willing to take that risk. Therefore, the decision regarding the disclosure of previous application can affect competition not only in a static sense, but also in a dynamic one by affecting lenders' incentives to innovate.

In order to shed further light on these issues we develop a two-stage model with two lenders, an incumbent and a challenger, where the latter is at a disadvantage due to a higher cost of capital (i.e., to reflect the higher risk profile when compared to an established incumbent). In the first stage both lenders have the common (i.e., non-exclusive) option to invest in a superior screening technology by incurring a sunk cost. In the second stage, each borrower aims to borrow a unit of funds, and lenders choose rates to offer borrowers. After observing the rates advertised by each lender borrowers submit an application to one of the lenders. This first lender approached issues a request for the borrower's credit report and uses the information contained in the credit report potentially along with the advanced screening methodology to determine the borrower's creditworthiness. After this screening procedure, the first lender decides whether or not to accept the borrower's application. If the first lender decides to reject the application, the borrower may approach another lender. Now when this second lender approached inspects the borrower's credit report they may or may not - depending on the amount of information recorded in the credit register - observe the request issued by the first lender. If the additional information is recorded, then the second lender can infer that the borrower's lending application wasn't successful and so may be less inclined to accept the borrower's application.

We focus on how the amount of information recorded in the credit register – in particular whether or not the credit register records loan requests from a borrower which were subsequently rejected by the lender – affects competition in second stage and, in turn, incentives to invest in the first stage.

We show that under the mainstream search request regime, whereby lenders can observe previous unsuccessful applications, lenders have lower incentives to invest in the advanced screening technology because borrowers demand a discount to compensate them for the risk of being rejected by the innovative lender and thus facing higher lending rates or being denied a loan. We show that under both disclosure regimes, only one lender will invest in the first stage, if any, therefore yielding an asymmetric configuration in the second stage. We also show that the challenger - who faces a higher funding cost than the incumbent – can be the one investing in the advanced screening technology only in the absence of disclosure of previous rejections.

1.1 Related literature

The traditional rationale for sharing credit data is to reduce the information asymmetry faced by competing lenders unable to observe the creditworthiness of perspective borrowers. This information asymmetry induces credit rationing due to the 'adverse selection' problem, whereby lenders raise interest rates or restrict loan amounts to discount the risk that prospective borrowers are not as good as claimed. This in turn penalises good borrowers in the absence of a credible signal of their creditworthiness. A 'moral hazard' problem can also be at play, as higher interest rates undermine the borrower's incentives to exert effort to reduce the risk of default (Stiglitz and Weiss, 1981).

In the absence of credit data sharing, the existing lender can acquire proprietary information on the borrower's creditworthiness, thus being able to exercise market power over 'locked-in' customers, thanks to the fact that rival lenders would still be constrained by the same information asymmetry. On the one hand, this 'hold-up problem' drives competition among lenders to acquire borrowers without a shared credit history with low interest rates initially (Sharpe, 1990). On the other hand, it adversely affects the owner's incentive to exert effort (Rajan, 1992). Under information sharing credit availability would improve. Rival lenders would find it easier to target good borrowers with poaching offers, which would tend to put downward pressure on lending rates. In turn, borrowers would have strong incentives to do well, in the knowledge that the current lender will not be able to opportunistically engage in rent extraction via uncompetitive lending rates (Padilla and Pagano, 1997).

At the initial screening stage, lenders face a 'winner's curse' problem (Broecker, 1990; and von Thadden, 2004), whereby the fact that the borrower didn't obtain a loan from any of the competing lenders entails that the lender that approved the loan request might have overestimated the borrower's creditworthiness. When lenders differ in their ability to screen perspective borrowers the adverse selection problem faced by the less informed lenders is more severe. The larger this asymmetry and the weaker is pricing rivalry (Broecker, 1990; von Thadden, 2004; Hauswald and Marquez, 2003; and Hauswald and Marquez, 2006). Hence, lenders have an incentive to invest in screening technologies to increase their advantage (Karapetyan and Stacescu, 2014), although to a lesser extent as the number of competitors increases (Hauswald and Marquez, 2006).[4] He at al. (2023) show that the competition-weakening effect induced by the screening gap among lenders can arise even when the presence of a screening advantage rests on obtaining borrowers' consent to access personal data.

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[4] Vives and Ye (2022) model duopolistic competition based on the linear 'city' framework. However, their model differs in two fundamental ways: *(i)* rejected borrowers exit the market, hence there is not adverse selection for the less informed lender; and *(ii)* the probability of borrower's success increases in the intensity of screening/monitoring. As a result, in contrast to Hauswald and Marquez (2006), borrowers benefit from a higher level of investment in the screening technology.

We expand the literature in a number of ways. First, we model the effect of the disclosure of previous unsuccessful applications under the mainstream search regime. To the best of our knowledge, this case has not been considered previously in the literature. This is potentially an important omission in the literature, given that the ability to observe previous unsuccessful applications can not only alter lenders' strategies, but also add a novel strategic dimension to borrowers' conduct.[5] Second, we compare the mainstream search regime, taking into consideration the impact of disclosure of previous unsuccessful applications, with a soft search regime whereby previous unsuccessful applications are not disclosed, as in the standard one-period model of lending competition where lenders compete by offering rates simultaneously. As we show, the core results in Hauswald and Marquez (2003, 2006) rest on the implicit assumption that previous applications are not disclosed, as otherwise the outcomes, both in terms of lending and prior incentives to acquire better information, would differ radically. Third, we model a different second source of heterogeneity among competing lenders, which is not exogenously tied to the screening gap, by assuming that one lender has lower (funding) costs, as it may be the case when an established incumbent competes against a new entrant. Finally, we investigate how lenders' incentives to invest in the advanced screening technology differ between the two disclosure regimes.

2 Model set-up

There are two lenders ($j \in A, B$) and a continuum of borrowers ($i \in [0,1]$). With probability $\mu \in (0,1)$ borrower i is a safe borrower (of type $\theta = H$) and with probability $1 - \mu$ borrower i is a risky borrower (of type $\theta = L$). Each borrower seeks to borrow a unit of funds from one of the lenders in order to pursue a project. A safe borrower repays a loan in

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[5] Doerr et al. (2023) develop a one-period spatial model of lending competition where two traditional banks are located at the extremes of a Hotelling line, whereas a third fintech lender with a screening advantage does not have 'transport costs', but requires applicants to disclose more personal data which entails a higher disutility. As a result, the fintech lender must compensate applicants for the higher privacy cost.

full with certainty, whereas a risky borrower always fail and thus never pays back a loan. As in Hauswald & Marquez (2003, 2006), borrowers do not know whether they are safe or risky and the distribution of borrower types is common knowledge.

There are two stages. In the first stage, both lenders decide whether or not to invest in a screening technology by paying a fixed (and sunk) cost f in order to receive a noisy signal $s \in H, L$ for each borrower. A lender who invested in the screening technology is labelled innovative, as opposed to a traditional lender. Crucially, borrowers can observe whether a lender has invested in the first stage. Following Hauswald & Marquez (2003, 2006), the precision of the signal is given by: $P(s = H|\theta = H) = P(s = L|\theta = L) = \frac{1+\sigma}{2}$, and $P(s = H|\theta = L) = P(s = L|\theta = H) = \frac{1-\sigma}{2}$. Note that in the special case where $\sigma = 0$ the signal is uninformative and is uncorrelated with borrower type. In contrast, when $\sigma = 1$ the signal is perfectly informative. Finally we assume that if both lenders invest in the screening technology then they both receive the same signal.[6]

We consider a setting where the two lenders have different business models and hence have different costs of capital.[7] In particular, lender j must pay c_j to raise a unit of funds, and without loss of generality we assume that $c_A \leq c_B$. Henceforward, we label lender A the low-cost lender and lender B the high-cost lender. Borrowers are only willing to borrow funds at a rate less than or equal to r_0.[8] Borrowers who choose not to borrow funds will not pursue a project. We assume throughout that: $\mu r_0 > c_B$. This ensures that if neither lender

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[6] This can capture a scenario where innovative lenders are likely to develop similar signalling technologies (perhaps because both signalling technologies rely on the same third party providers to access data and / or algorithms).

[7] For example, the high-cost lender may be a small / new lender with a higher cost of equity due to a higher risk of failure and / or a non-bank lender without access to cheap source of debt-funding such as retail insured deposits.

[8] It is irrelevant whether borrowers can observe which lender has a cost of funding advantage.

invests in the screening technology, the high cost lender is willing to lend to any borrower at rate r_0.

In the pricing stage that follows the investment stage, lenders compete for borrowers in a Bertrand fashion. Pricing strategies depend on whether or not requests for loans which are subsequently rejected are recorded. We now describe each of these two possibilities in turn.

Under the soft searches regime lenders cannot observe whether a certain borrower has applied for credit with their competitor in the pricing stage. This means that: *(i)* all borrowers have an incentive to apply to both lenders and then choose the most favorable offer; and *(ii)* it does not matter which lender is approached first. In order to model this case we assume that in the second stage both lenders simultaneously offer each borrower an interest rate. If the lowest interest rate offered to a certain borrower is less than r_0, then this borrower accepts funds from the lender offering the lowest interest rate and starts a project. Otherwise the borrower chooses not to start a project.

In contrast, under the mainstream search regime lenders can observe whether a certain borrower has applied for credit with their competitor, since this request is recorded in the borrower's credit report. In this case, it may matter which lender is approached first, particularly when only one lender invests in the advanced screening technology and lenders have access to different information. In order to model this case, we assume borrowers first approach one of the lenders and if rejected then approach the other lender. . Having described the model we now proceed to the analysis.

3 Analysis

We first introduce some extra notation. For lender $j \in A, B$, $c_{j|H}$ denotes the lowest rate that lender j could offer to a borrower with a high signal without making an expected loss, that is: $P(\theta = H|s = H)c_{j|H} = c_j$. Applying the Bayes theorem gives:

$$P(\theta = H|s = H) = \frac{P(\theta = H)P(s = H|\theta = H)}{P(s = H)} = \frac{\mu(1 + \sigma)}{1 + \sigma(2\mu - 1)} < 1$$

Hence: $c_{j|H} = c_j \frac{1+\sigma(2\mu-1)}{\mu(1+\sigma)}$. Similarly, we define $c_{j|L} = c_j \frac{1-\sigma(2\mu-1)}{\mu(1-\sigma)}$ which denotes the lowest rate that lender j could offer to a borrower with a low signal without making an expected loss. Finally, we define $c_{j|\emptyset} = \frac{c_j}{\mu}$, which denotes the lowest rate that lender j could offer to a borrower without making an expected loss in the scenario where neither lender invests in the advanced screening technology. When the signal is completely uninformative (with $\sigma = 0$), $c_{j|H} = c_{j|L} = c_{j|\emptyset}$, while as the signal becomes completely informative (with $\sigma \to 1$), $c_{j|H} \approx c_j$ and $c_{j|L} \approx \infty > r_0$. Intuitively, the higher the precision of the signal (as σ increases) and the lower (higher) $c_{j|H}$ ($c_{j|L}$) is compared to $c_{j|\emptyset}$.[9], whereas an increase in the proportion of safe borrowers (as μ increases) reduces both break-even rates.[10]

Note that if the signal is completely uninformative (with $\sigma = 0$), then $r_A = r_B = c_{B|\emptyset}$ and all borrowers approach the low-cost lender. This is analogous to the case where lenders with different marginal cost compete in a complete information environment (see Broecker, 1990). We restrict the analysis to a scenario where the signal is highly informative (with $\sigma \approx 1$), so that none of the lenders is willing to lend to a borrower with a low signal (since $r_0 < c_{A|L} < c_{B|L}$). This is also when investing in the advanced screening technology is more likely to be welfare improving. Therefore, henceforth we assume that this is the case. The model is solved backward starting with the pricing stage.

3.1 The pricing stage

We first discuss the outcome of the pricing stage in the case where both lenders chose to invest in the advanced screening technology. Note that in this case both lenders have access to the same information. Therefore, the outcome is the same regardless of the chosen disclosure regime. If the signal is low, then neither lender will offer the borrower credit (since $r_0 < c_{A|L} < c_{B|L}$). Meanwhile, if the signal is high, lenders offer a rate $r_A = r_B = c_{B|H}$, and all borrowers approach the low-cost lender. Note that if both lenders invest in the

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[9] $\frac{\vartheta c_{j|H}}{\vartheta \sigma} = -c_j \frac{2(1-\mu)}{\mu(1+\sigma)^2} < 0$ and $\frac{\vartheta c_{j|L}}{\vartheta \sigma} = c_j \frac{2(1-\mu)}{\mu(1-\sigma)^2} > 0$.

[10] $\frac{\vartheta c_{j|H}}{\vartheta \mu} = -c_j \frac{1-\sigma}{\mu^2(1+\sigma)} < 0$ and $\frac{\vartheta c_{j|L}}{\vartheta \sigma} = -c_j \frac{1+\sigma}{\mu^2(1-\sigma)} < 0$.

advanced screening technology, then the high-cost lender never serves any borrowers. The case where neither lender invests is similar: both lenders offer a rate $r_A = r_B = c_{B|\emptyset}$ and the high-cost lender makes no profits (regardless of the chosen disclosure regime).

For the rest of this section we consider the main case of interest where there is asymmetric information in that only one lender invests in the advanced screening technology. We use $I \in A, B$ to denote the innovative lender and $T \in A, B$ to denote the traditional lender (note $I \neq T$).

First we consider the case under the soft search regime. As it is well established (Broecker, 1990; von Thadden, 2004), when a lender enjoys an information advantage over a rival, the equilibrium solution is in mixed strategies.[11] Hauswald and Marquez (2003, 2006; Proposition 1) showed that there exist a unique equilibrium in mixed strategies. What follows is a restatement of that result for a case where competing lenders have different (marginal) cost:

Proposition 3.1. *Under the soft search request regime and if in the investment stage exactly one of the lenders choose to innovate. Then in the pricing stage:*

1. *The innovative lender offers funding to all borrowers with a high signal,*
2. *The innovative lender does not offer funding to borrowers with a low signal,*
3. *The traditional lender offers funding to some (but not all) borrowers,*
4. *Borrowers offered funding accept an interest rate in the range* $[c_{T|\emptyset}, r_0)$,
5. *Some borrowers with a low signal are not funded,*

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[11] On the one hand, the uninformed lender has the incentive to undercut the informed rival by setting a rate not below the break-even rate on an ex-ante basis. On the other hand, as the informed lender can undercut by setting a rate below the break-even point thereof, the uninformed lender face the risk of adverse selection, which entails that the rate should be set at a higher level.

6. The innovative lender' makes profits (on an ex-ante basis and gross of the initial investment cost) equal to:

$$E\left(\pi_I^{(s)}\right) = \frac{c_T(1+\sigma)-c_I[1+\sigma(2\mu-1)]}{2} = c_T P(s=H|\theta=H) - c_I P(s=H) \text{ and}$$

7. The traditional lender makes zero profits (on an ex-ante basis).

Proof. See the appendix.

In contrast to Hauswald and Marquez (2003, 2006), the lender with the information advantage does not always make positive profits. The break-even condition with respect to the difference between the two lenders in terms of cost of funding is given by:

$$E\left(\pi_I^{(s)}\right) \geq 0 \leftrightarrow \frac{c_T}{c_I} \geq \frac{1+\sigma(2\mu-1)}{1+\sigma} = \frac{P(S=H)}{P(s=H|\theta=H)} = \frac{P(\theta=H)}{P(\theta=H|s=H)} < 1$$

When the innovative lender is the low-cost lender, the above condition is always satisfied, whereas the same does not hold when the innovative lender is the high-cost lender. An increase in the degree of adverse selection (as σ and thus $P(s=H|\theta=H)$ increases) makes the condition less tight,[12] which is intuitive as the traditional lender is forced to raise its rates (i.e., more likely to bid higher rates under the corresponding probability distribution), thus inducing the innovative lender to follow suit, which in turn results in higher profit margins.[13] In contrast, an increase in the proportion of safe borrowers (as $\mu = P(\theta=H)$ increases) makes the condition tighter, as the adverse selection risk faced by the traditional lender is mitigated, thus intensifying pricing rivalry, which in turn results in lower profit margins for the innovative lender. Therefore, the option to invest in the

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[12] The partial derivative with respect to σ of the expression in the right-end side of the inequality is given by: $\frac{2\mu-2}{(1+\sigma)^2} < 0$.

[13] Therefore, in line with Hauswald and Marquez (2003, 2006), better information increases profits overall (thanks to the increase in profit for the innovative lender), but makes borrowers who receive a loan worse off (due to higher rates across both lenders).

advanced screening technology may not be viable for the high-cost lender under a combination of low level of precision of the signal and high proportion of safe borrowers.

We now turn to the case under the mainstream search regime. We define $\Delta_I^{(rp)} > 0$, which we call rejection premium, to be the unique value satisfying the following equation:

$$r_0 - c_{T|\emptyset} = P(s = H)\left[r_0 - \left(c_{T|\emptyset} - \Delta_I^{(rp)}\right)\right]$$

The left-hand side captures the borrower surplus associated with approaching a traditional lender who always offers a rate $r_T = c_{T|\emptyset}$. The right-hand side captures the expected consumer surplus associated with approaching an innovative lender who offers a rate $r_I = c_{T|\emptyset} - \Delta_I^{(rp)}$ with probability $P(s = H)$. By solving for $\Delta_I^{(rp)}$ gives:

$$\Delta_I^{(rp)} = (r_0 - c_{T|\emptyset})\frac{1 - \sigma(2\mu - 1)}{1 + \sigma(2\mu - 1)} = (r_0 - c_{T|\emptyset})\frac{P(s = L)}{P(s = H)}$$

The higher the proportion of safe borrowers (as μ increases), the lower the discount must be to compensate borrowers for the risk of being rejected.[14] Whereas, an improvement in the precision of the signal (as σ increases) leads to an increase in the discount when there are more risky than safe borrowers (with $\mu < \frac{1}{2}$), and vice versa.[15] The following result describes equilibrium behavior in the pricing stage under the mainstream search request regime:

Proposition 3.2. *Under the mainstream search request regime and if in the investment stage exactly one of the lenders choose to innovate. Then in the pricing stage:*

1. *All borrowers approach the innovative lender and are offered a rate:*

$$r_I = \left(c_{T|\emptyset} - \Delta_I^{(rp)}\right),$$

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14 $\frac{\vartheta \Delta_I^{(rp)}}{\vartheta \mu} = -\left(c_{T|\emptyset} - \Delta_I^{(rp)}\right)\frac{4\sigma}{[1+\sigma(2\mu-1)]^2} < 0.$

15 $\frac{\vartheta \Delta_I^{(rp)}}{\vartheta \sigma} = \left(c_{T|\emptyset} - \Delta_I^{(rp)}\right)\frac{2-4\mu}{[1+\sigma(2\mu-1)]^2}.$

2. All borrowers with a high signal are accepted by the innovative lender,

3. All borrowers with a low signal are not funded,

4. The innovative lender' makes profits (on an ex-ante basis and gross of the initial investment cost) equal to:[16]

$$E\left(\pi_I^{(m)}\right) = \left[\frac{2c_{T|\emptyset} - r_0\left(1-\sigma(2\mu-1)\right)}{1+\sigma(2\mu-1)}\right]\frac{\mu(1+\sigma)}{2} - c_I\,\frac{1+\sigma(2\mu-1)}{2}, \textit{ and}$$

5. The traditional lender is not active and thus makes zero profits.

Although the traditional lender does not initially observe any signal about the borrower's type, under the mainstream search regime the traditional lender can observe if a borrower has previously approached the innovative lender. In such a situation the traditional lender can infer that the borrower in question is a low type (since otherwise they would have been given a loan by the innovative lender), and hence will not be willing to lend to this borrower (since $r_0 < r_{B|\mathrm{L}}$). This creates a dynamic whereby borrowers only submit one request before their type is revealed. In this case the innovative lender must price sufficiently low (setting $c_{I|H} < r_I < r_T = c_{T|\emptyset}$) so that borrowers prefer to take a risk and apply with the innovative lender (hoping to obtain a rate r_I) rather than the traditional lender (and obtain a rate r_T with certainty).

This result rests on the assumption that borrowers can identify the innovative lender. In practice we believe there are many credit markets that fit these criteria, for instance when certain (innovative) lenders request a large amount of information before making a credit decision and other (traditional) lenders are willing to make a credit decision very quickly based on, little information. For example, lenders relying on non-traditional sources of information may be required to obtain consent from the prospective borrower under privacy protection rules.

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[16] The expected profit for the innovative lender is obtained from the following formula: $E\left(\pi_I^{(m)}\right) = P(s = H)\left[P(\theta = H|s = H)\left(c_{T|\emptyset} - \Delta_I^{(rp)}\right) - c_I\right]$.

The disclosure of previous unsuccessful applications drastically changes the type of equilibrium from one in mixed strategies, where both lenders are active so that some borrowers with a low signal obtain a loan, to one in pure strategies, where only the innovative lender is active so that none of the borrowers with a low signal get a loan.

Similarly to the previous regime, the lender with the information advantage does not always make positive profits. The corresponding break-even condition with respect to the difference between the two lenders in term of cost of funding is given by:

$$E\left(\pi_I^{(m)}\right) \geq 0 \leftrightarrow \frac{c_T}{c_I} \geq \frac{r_0}{c_{I|\emptyset}} \frac{1-\sigma(2\mu-1)}{2} + \frac{[1+\sigma(2\mu-1)]^2}{2(1+\sigma)}$$

In contrast to the previous regime, the above condition is not always satisfied when the innovative lender is the low-cost lender. Indeed, the break-even threshold (the right-hand side of the inequality above) under the mainstream search request regime is always greater than under the soft search request regime.[17] The following corollary generalizes this result.

Corollary 3.1. *The expected profit of the innovative lender is higher under the soft search request regime:* $E\left(\pi_I^{(s)}\right) > E\left(\pi_I^{(m)}\right)$.

Proof: See the appendix.

Hence, the soft search request regime is more accommodative with respect to viability of the investment in the advanced screening technology. The following section analyses these aspects in more detail.

3.2 The investment stage

[17] The comparison between the two break-even thresholds is given by: $\frac{r_0}{c_{I|\emptyset}} \frac{1-\sigma(2\mu-1)}{2} + \frac{[1+\sigma(2\mu-1)]^2}{2(1+\sigma)} > \frac{1+\sigma(2\mu-1)}{1+\sigma}$. This can be rearranged as follows: $\frac{1-\sigma(2\mu-1)}{2}\left[\frac{r_0}{c_{I|\emptyset}} - \frac{1+\sigma(2\mu-1)}{1+\sigma}\right] > 0$. Given that $\frac{r_0}{c_{I|\emptyset}} > 1$ and $\frac{1+\sigma(2\mu-1)}{1+\sigma} < 1$ the inequality always holds.

As explained at the beginning of the previous section, when both lenders invest in the first stage the low-cost lender lend to borrowers with a high signal at $c_{B|H}$, whereas the high-cost lender is inactive. Therefore, the expected profit for the former, net of the investment cost, is given by (regardless of the disclosure regime: $E(\pi_{A|YY}) = P(s = H)\left[P(\theta = H|s = H)c_{B|H} - c_A\right] - f = \frac{1+\sigma(2\mu-1)}{2}(c_B - c_A) - f$

Whereas, the high-cost lender incurs a loss equal to the initial sunk cost. It is interesting to observe that, contrary to the asymmetric scenario, the level of expected profit of the low-cost lender improves as the proportion of safe borrowers increases, which is intuitive given that a low proportion of safe borrowers does not benefit the innovative lender in the absence of adverse selection. If neither lender invest the outcome is the same regardless of the disclosure regime. Specifically, the low-cost lender (lender A) serves all customers and earns a positive expected profit given by: $E(\pi_{A|NN}) = \mu c_{B|\emptyset} - c_A = c_B - c_A$, whereas the high cost lender (lender B) is not active and thus makes no profit. When only one lender invests in the advanced screening technology, the net profit for the innovative lender is given by: $E(\pi_{j|YN}) = E\left(\pi_{I=j}^{(x)}\right) - f, x \in \{s, m\}$, whereas the traditional lender makes zero profit regardless of the disclosure regime, although on expectation under the soft search request regime and with certainty, given inactivity, under the mainstream search request regime.

The following table summarizes this analysis with the pay-off matrix at the first stage:

		B	
		Invest	Not invest
A	Invest	$\left(E(\pi_{A|YY}), -f\right)$	$\left(E(\pi_{A|YN}),0\right)$
	Not invest	$\left(0, E(\pi_{B|YN})\right)$	$\left(E(\pi_{A|NN}),0\right)$

With respect to the comparison between the two symmetric scenarios, the non-investment scenario dominates the opposite one in that the level of profit for both lenders is higher than in the investment scenario. In the absence of information asymmetry between the two lenders, the low-cost lender can only extract the rent arising from the comparative advantage in terms of funding costs. However, in the symmetric investment scenario rent extraction is curtailed by the sunk cost and the fact that lending is limited to borrowers with a high-signal and at a lower price, which more than offset the fact that an informed lender is less likely to lend to risky borrowers. In addition, since the low-cost lender is better off by (unilaterally) not investing, this scenario cannot be an equilibrium.

There are three comparisons that determine whether there are, if any, Nash solutions in pure-strategies to the two-dimensional matrix presented above: *i)* $E(\pi_{A|YN}) > E(\pi_{A|NN})$; *ii)* $E(\pi_{B|YN}) > 0$; and *iii)* $E(\pi_{A|YY}) > 0$. There can be three such equilibria: *a)* if *i)* holds, the top-right quadrant with the low-cost lender investing; *b)* if *ii)* holds but *iii)* doesn't, the bottom-left quadrant with the high-cost lender investing; and *c)* if neither *i)* nor *ii)* hold, the bottom-right quadrant with neither lender investing. Finally, if *ii)* and *iii)* hold but *i)* doesn't, there is no Nash equilibrium in pure strategies.

The following two propositions summarise the application of the analytical framework outlined above to the two disclosure regimes.

Proposition 3.3. *Under the soft search request regime, there is always at least one equilibrium in pure strategies. Specifically, there can be one of the following three configurations:*

- *Under a combination of small difference in the cost of funding, low proportion of safe borrowers and high precision of the signal, when compared to the investment sunk cost, only the low-cost lender invests;*
- *Under an even stronger combination of small difference in cost of funding, low proportion of safe borrowers and high precision of the signal, when compared to the investment sunk cost, both asymmetric scenarios where either lender invest; and*
- *Under a combination of large difference in the cost of funding, high proportion of safe borrowers and high precision of the signal, when compared to the investment sunk cost, none of the lenders invest.*

Proof. See the appendix.

The conditions underpinning the existence of the equilibrium where the low-cost lender invests are always easier to meet than the corresponding ones for the opposite asymmetrical outcome where the high-cost lender invests. This is because the incremental profit earned by the low-cost lender upon investing unilaterally is always higher than the corresponding profit earned by the high-cost lender. Although the absolute level of profitability of the low-cost lender improves when the corresponding advantage in terms of cost of funding widens, the incentives to invest (unilaterally) are weakened because the level of profit that can be earned under the non-investment symmetric configuration are higher. Therefore, a smaller gap between the two lenders in terms of cost of funding improves the conditions for both lenders to invest (unilaterally). In contrast, a larger gap in terms of cost of funding increases the investment incentives of the low-cost lender when the high-cost lender also invests. Similarly, as pointed out above, whilst a greater risk of adverse selection improves the incentives to invest unilaterally, the opposite is the case with respect to the incentive of the low-cost firm to invest when the high-cost lender also invests.

Proposition 3.4. *Under the mainstream search request regime, there is always at least one equilibrium in pure strategies. Specifically, there can be one of the following two configurations:*

- *Under a combination of small difference in the cost of funding, low proportion of safe borrowers and high precision of the signal, when compared to the investment sunk cost, only the low-cost lender invests;*
- *Under a combination of large difference in the cost of funding, high proportion of safe borrowers and high precision of the signal, when compared to the investment sunk cost, none of the lenders invest.*

Proof. See the appendix.

Similarly to the previous case, the incremental profit earned by the low-cost lender upon investing unilaterally is always higher than the corresponding profit earned by the high-cost lender. This is more so under the mainstream search request regime when the proportion of safe borrowers is low and the precision of the signal is high, which are conditions underpinning the profitability of (unilateral) investment in the advanced screening technology. In addition, in contrast to the previous regime, the incremental profit that the low-cost lender can earn by matching the investment of the high-cost lender is always greater than the profit earned by the high-cost lender when the low-cost lender does not invest. Hence, the latter configuration does not arise in equilibrium.

Taking into consideration the result under Corollary 3.1 that the profit of the innovative lender under the asymmetric configuration is always higher under the soft search request regime, these findings confirm that the mainstream search request regime is less accommodative with respect to viability of the investment in the advanced screening technology, especially with respect to the incentives of the high-cost lender.

4 Conclusions

It is well established that the sharing of credit histories among competing lenders can be beneficial not only for 'locked-in' borrowers, thus maintaining their incentives to exert effort, but also for lenders collectively, as it reduces adverse selection. However, it has been argued that the disclosure of previous applications (i.e., those that did not result in loan originations) can distort competition by dissuading prospective borrowers to shop around, wary that the observation of credit searches logged by other lenders could be attributed to previous rejections.

We identify another potential unintended consequence with this type of disclosure. When competing lenders differ in their screening ability and the prospective borrower is less informed about her creditworthiness, the latter might shun the lender with a screening advantage in order to maintain opacity. This is because if the prospective borrower approaches the innovative lender, there is a risk of being rejected and thus exposed as a risky borrower. Hence, the prospective borrower will only approach the innovative lender if the rate offered by the innovative lender sufficiently compensates the borrower for the possibility of rejection.

On the one hand, under the mainstream search request regime, as the lender with a known screening advantage need to compensate applicants for the risk of rejection, those who end up being approved for a loan benefit from lower rates. In addition, disclosure allows the lender without a screening advantage to better identify applicants with low credit scoring, thus improving the efficiency of credit allocation across the board. However, these two positive effects hinge upon lenders being willing to invest to acquire a screening advantage in the first place, but the disclosure of previous failed applications reduces the viability of the investment. This is especially the case for lenders already facing a competitive disadvantage due to, for example, a higher cost of funding.

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Appendix: Proofs

Proof of Proposition 3.1 (Sketch).

We follow Hauswald and Marquez (2003). The (uninformed) traditional lender must make zero profit at the lowest possible rate $\underline{r}$, so that: $\underline{r}\mu - c_T = 0 \rightarrow \underline{r} = c_{T|\emptyset}$. Upon observing a high signal, the innovative (informed) lender bids and obtains expected profit: $\underline{r}P(\theta = H|s = H) - c_I = \frac{c_T(1+\sigma)}{1+\sigma(2\mu-1)} - c_I = \overline{\pi}$. Accordingly, the expected profit for the innovative lender is given by: $P(S = H)\overline{\pi}$.

Proof of Corollary 3.1.

By substituting and rearranging the inequality $E\left(\pi_I^{(s)}\right) > E\left(\pi_I^{(m)}\right)$ can be simplified as follows: $c_T(1 + \sigma)\left[\frac{1}{2} - \frac{1}{1+\sigma(2\mu-1)}\right] + r_0\frac{[1-\sigma(2\mu-1)]\mu(1+\sigma)}{2[1+\sigma(2\mu-1)]} > 0$. By replacing r_0 with $c_{T|\emptyset}$ and simplifying, the expression on the left-hand side becomes zero. Given the assumption that $\mu r_0 > c_B$, the inequality is always satisfied.

Proof of Proposition 3.3.

First of all, the lack of equilibrium in pure strategies requires that: *i)* $E(\pi_{A|YN}) < E(\pi_{A|NN})$; *ii)* $E(\pi_{B|YN}) > 0$; and *iii)* $E(\pi_{A|YY}) > 0$. However, the first and second conditions cannot be satisfied together. $E(\pi_{A|YN}) - E(\pi_{A|NN}) = \frac{c_A[1-\sigma(2\mu-1)]-c_B(1-\sigma)}{2} - f$, whereas $E(\pi_{B|YN}) = \frac{c_A(1+\sigma)-c_B[1+\sigma(2\mu-1)]}{2} - f$. Accordingly, $E(\pi_{A|YN}) - E(\pi_{A|NN}) - E(\pi_{B|YN}) = \frac{\sigma 2\mu(c_B-c_A)}{2} > 0$. Therefore, whenever condition two is satisfied, it must be the case that $E(\pi_{A|YN}) > E(\pi_{A|NN})$. This in turn entails that there can be parameters configurations whereby the condition for the existence of an equilibrium in pure strategies where the low-cost lender invests, $E(\pi_{A|YN}) > E(\pi_{A|NN})$, is satisfied, whereas at least one of the two conditions for the existence of an equilibrium in pure strategies where the high-cost lender invests, $E(\pi_{B|YN}) > 0$, is not satisfied. Indeed, for both $E(\pi_{B|YN}) > 0$ and $E(\pi_{A|YY}) < 0$ to hold, it must be the case that $E\left(\pi_{I=B}^{(s)}\right) > E(\pi_{A|YY}) + f$. By substituting the corresponding expressions for the expected profits, this inequality can be rearranged as follows: $\frac{c_B}{c_A} >$

$\frac{1}{2}\left[1+\frac{1+\sigma}{1+\sigma(2\mu-1)}\right]$. This inequality is harder to satisfy than the analogous inequality underpinning condition $E\left(\pi_{I=B}^{(s)}\right)>0, \frac{c_B}{c_A}>\frac{1+\sigma}{1+\sigma(2\mu-1)}$, which in turn is harder to satisfy than the analogous inequality underpinning the condition $E(\pi_{A|YN})+f-E(\pi_{A|NN})>0, \frac{c_B}{c_A}>\frac{1-\sigma(2\mu-1)}{1-\sigma}$. All the three inequalities are easier to satisfy for a combination of small difference in the cost of funding, low proportion of safe borrowers and high precision of the signal. This in turn entails that for $E(\pi_{A|YN})>E(\pi_{A|NN})$ not to hold, so that the only equilibrium in pure strategies is with no investment at all, it must be due to a combination of large difference in the cost of funding, high proportion of safe borrowers and low precision of the signal, when compared to the investment sunk cost.

Proof of Proposition 3.4.

As for the previous proposition, the lack of equilibrium in pure strategies requires that: *i)* $E(\pi_{A|YN})<E(\pi_{A|NN})$; *ii)* $E(\pi_{B|YN})>0$; and *iii)* $E(\pi_{A|YY})>0$. However, the first and second conditions cannot be satisfied together. $E(\pi_{A|YN})-E(\pi_{A|NN})=c_A\frac{1-\sigma(2\mu-1)}{2}-r_0\frac{[1-\sigma(2\mu-1)]\mu(1+\sigma)}{2[1+\sigma(2\mu-1)]}+c_B\frac{2\sigma(1-\mu)}{1+\sigma(2\mu-1)}-f$, whereas $E(\pi_{B|YN})=c_A\frac{1+\sigma}{1+\sigma(2\mu-1)}-r_0\frac{[1-\sigma(2\mu-1)]\mu(1+\sigma)}{2[1+\sigma(2\mu-1)]}-c_B\frac{1+\sigma(2\mu-1)}{2}-f$. Accordingly, $E(\pi_{A|YN})-E(\pi_{A|NN})-E(\pi_{B|YN})=\frac{1+2\sigma+[\sigma(2\mu-1)]^2}{2[1+\sigma(2\mu-1)]}(c_B-c_A)>0$. Therefore, whenever condition two is satisfied, it must be the case that $E(\pi_{A|YN})>E(\pi_{A|NN})$. This in turn entails that there can be parameters configurations whereby the condition for the existence of an equilibrium in pure strategies where the low-cost lender invests, $E(\pi_{A|YN})>E(\pi_{A|NN})$, is satisfied, whereas at least one of the two conditions for the existence of an equilibrium in pure strategies where the high-cost lender invests, $E(\pi_{B|YN})>0$, is not satisfied. Indeed, there cannot be an equilibrium in pure strategies where the high-cost lender invests, given that whenever $E(\pi_{B|YN})>0$, it must also be the case that $E(\pi_{A|YY})>0$. This is to the extent that $E\left(\pi_{I=B}^{(m)}\right)<E(\pi_{A|YY})+f$. By substituting the corresponding expressions for the expected profits, this inequality can be rearranged as follows: $c_A[3+4\sigma\mu+\sigma^2(2\mu-1)^2]-c_B[2+4\sigma\mu+\sigma^2(2\mu-1)^2]-r_0[1-\sigma(2\mu-1)]\mu(1+\sigma)<0$. Given that $c_A<c_B, r_0>\frac{c_B}{\mu}$ and $[1-\sigma(2\mu-1)](1+\sigma)>1$, the inequality is always satisfied. Finally, if $E(\pi_{A|YN}) < E(\pi_{A|NN})$, the only equilibrium in pure strategies is with no investment at all. This requires that $c_A \frac{1-\sigma(2\mu-1)}{2} - r_0 \frac{[1-\sigma(2\mu-1)]\mu(1+\sigma)}{2[1+\sigma(2\mu-1)]} + c_B \frac{2\sigma(1-\mu)}{1+\sigma(2\mu-1)} - f < 0$, which is satisfied for a combination large difference in the cost of funding, high proportion of safe borrowers and high precision of the signal, when compared to the investment sunk cost.